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In re application of: **Saliahov**

U.S. Serial Number: 09/943,876

Filing Date: August 31, 2001

Art Unit: 2131

Examiner: To Be Assigned

Our Reference Number: 240703-1200

Title: Optical Disc Authentication Method and Apparatus

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PATENT #4

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In Re Application of:

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Saliahov

Group Art Unit: 2131

Serial No.: 09/943,876

Examiner: To Be Assigned

Filed: August 31, 2001

Docket No. 240703-1200

For: **OPTICAL DISC AUTHENTICATION METHOD AND APPARATUS**

CLAIM OF PRIORITY TO AND SUBMISSION OF CERTIFIED COPY OF CANADIAN APPLICATION PURSUANT TO 35 U.S.C. §119

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Sir:

In regard to the above-identified pending patent application and in accordance with 35 U.S.C. §119, Applicant hereby claims priority to and the benefit of the filing date of Canaidan patent application entitled, ""CD-Disk Identification Through a Pattern Analysis", filed September 1, 2000, and assigned serial number 2,318,310. Further pursuant to 35 U.S.C. §119, enclosed is a certified copy of the Canadian patent application

Respectfully Submitted,

THOMAS, KAYDEN, HORSTEMEYER & RISLEY, L.L.P.

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La présente atteste que les documents ci-joints, dont la liste figure ci-dessous, sont des copies authentiques des documents déposés au Bureau des brevets.

This is to certify that the documents attached hereto and identified below are true copies of the documents on file in the Patent Office.

Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,318,310**, on September 1, 2000, by **OLEG SA[illegible]HOV**, for "CD-Disk Identification Through a Pattern Analysis".

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CD-DISK IDENTIFICATION THROUGH A PATTERN ANALYSIS

Field of the Invention

This invention relates to digital storage devices, and more particularly to providing for the identification of original digital (optical) storage device such as optical information storage discs.

Background of the Invention

The use of optical information storage discs, known as "compact discs", "CD-ROMs", "CDs" or "DVDs" has increased in popularity across various industries. Music and computer software are regularly distributed on compact discs.

Companies are increasingly being faced with illegal copying and distribution of copy righted music, video, computer software or other digitized information. This activity has been facilitated by technical advances which have decreased the cost of digital, optical, computer equipment and other duplicating apparatus. Duplicating equipment has become more accessible and as result illegal copying has increased during the last few years. Copy right owners of material contained on compact disks are faced with additional problems as the distinction between legal and illegal disks has become smaller.

Discussing the prior art

The most common technique for the compact disk authorization is the writing of distinguishing signs (marks) on the compact disk together with written information. Many of these marks will comprise information which can not be copied correctly onto an illegal copy or information which is related to a particular physical location on the compact disk.

For example, in United States Patent 5,696,757 "Optical disc, device for checking optical disc and device for recording information on optical disc", Ozaki, discloses a method wherein irregular pits are formed onto the surface of the optical disc. These irregular pits are arranged according a special algorithm such that they can not be copied. This includes cases when a normal optical disc containing such an irregular pit is copied by performing a conventional copying method. Thus, an illegally copied disk can be distinguished from an authentic compact disk by determining whether or not an irregular pit is included in the suspect compact disk. This method facilitates copyright protection by making it easy to detect an illegally copied disc and/or by causing any intended use of the illegal disc to fail.

U.S. Patent 5,881,038 for "Method and apparatus for preventing illegal copy or illegal installation of information of optical recording of information of optical recording medium", Oshima, discloses a method wherein a physical feature of a ROM type disk is extracted and encrypted before being recorded in an optical disc. The cipher is reproduced and converted into a plain text physical feature, which in turn, is compared with the physical feature information of an authentic disk. The operation of the system stops when the encryption/plain text is incorrect, thereby preventing the use of an illegally duplicated disc.

Another technique is based on a method where an identifier is embedded in one or more of the parity bytes which are always appended to the end of data frames for the purpose of detecting and correcting errors in the data frames as they are read from the digital storage devises by playback devices reading the predetermined code writing.

Other techniques are based on a serial number of each particular compact disk. This serial number is related with a password that is contained in the program. Software verifies the serial number of the disk with the related password of the program during installation. If the password are confirmed during the installation the program can be run.

All of the above mentioned methods do not solve the problem of universal identification of all disc types including audio CD, DVDs, CD ROM. One would like to protect software or other binary information of this nature with means that do not require a complicated mastering process.

Summary of the Invention

The invention is directed to a digital storage devices, and more particularly to providing for the identification of original digital (optical) storage device such as optical information storage discs

The structure and operation of various embodiments of the invention, will become apparent to those ordinarily skilled in the art upon review of the following description of the invention in conjunction with the accompanying drawings.

Brief Description of the Drawings

The invention will be described with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic cross section view of a compact disc

FIG. 2 is a tabular structure of an array with sector reading time information

FIG. 3 is a flowchart of the calculation of cache buffer memory

FIG. 4 is a schematic plan view of a compact disc

FIG. 5 is a graph of time of reading of sectors on compact disk.

FIG. 6 is a graph of time of reading of sectors on compact disk before data processing

FIG. 7 is a tabular structure of an array with turn numbers and quantity of sector

Detailed Description of the Invention

The current invention uses distinctive features of compact discs that are inherent from the manufacturing process as a means of identifying authentic versus counterfeit copies.

Compact disc recording and information storage technology is known in the art, thus, only a brief summary of elements which are relevant to the current invention will be presented here.

FIG. 1 depicts schematically a cross section of compact disc 100. Compact disc 100 comprises is an aluminium layer 102 that is sandwiched between a polycarbonate base plate 104 and a protective polycarbonate layer 106. The aluminium layer 102 is made thin enough such that it is semi-transparent to light. This transparency allows one to read several multi-layer structures, which contain the aluminium layer, that have been placed on top of one other.

Data is stored on the aluminium layer 102. The aluminium layer has a trace in a form of a spiral path from the center to the edge of the compact disc. All information is recorded on the path in a binary format. The path contains "pits" 108 and "hills" 110 that represent "1" and "0". The spiral path that encircles the center of compact disc once is called a "way".

When reading information on a compact disc, a decoder focuses a laser beam 112 on the disc100 in a specific manner. The light passes through the protective polycarbonate film 106 and is focused 112 on the aluminium layer(s) 102 . When the light encounters a pit 108 the brightness of the reflected light diminishes in comparison to when the light encounters the flat portion of a particular section. A photo-diode, which converts photons of light into electrical pulses is placed in the path of the reflected light. The photo-diode will measure the changing brightness of the light as it encounters 'pits' and 'hills'. The controller of a decoder transforms the signals into bits of information, i.e. the decoder reads every bit of information.

The difference between different types of discs lies in recording format and length of sectors (bytes) on which all information is divided (ordered). But the recording format is

not important for this method of identification of discs. The format of recording of information affects on way of reading and decoding the information.

The manufacturing process of CD-ROM discs is briefly disclosed before. The binary information to be written onto the compact disc during recording is divided into sectors. Each sector contains user information and auxiliary information. The auxiliary information comprises the sector's identification information, marks of beginning, end of the sector and error correction information. The above mentioned structure of a sector is are common for most popular types of compact discs. While we have used the particular example of the CD-ROM structure, it should be understood that we can apply the same principals to other types of compact discs.

The division of all user information into separated sectors is related to the accuracy of the mastering and reading devices being used.

The capacity of a CD-ROM depends on whether it is a Mode 1 CD-ROM or Mode 2 CD-ROM XA.

The recommended maximum size of a CD-ROM is 76 minutes 30 seconds. It means that there are 336,300 sectors on a CD-ROM, including 166 sectors at the start of track 1 and several sectors for the file system. Generally there are 336,100 available sectors for user data.

Mode 1 sectors contain 2048 bytes per sector giving a total capacity of 688,332,800 bytes or 656MB. Mode 2 sectors contain either 2048 or 2324 bytes per sector so they will have a somewhat higher data capacity depending on the mix of the two types of sectors.

The first stage of mastering is the writing of user binary information onto an original compact disc which is known in industry as a "gold master".

Further, the original compact disk – "gold master" - is placed in an apparatus which is equipped with a high-energy laser that physically records data from the "gold master" onto a master disc that is often made of glass. The process itself includes covering the master disc with a photosensitive material. During the recording process the laser is pulsed where 'pits' are to be recorded on the disk. The laser pulses volatize the photosensitive layer which physically causes a pit to form.

The master disc recorded in this way provides an exact replica of the binary element sequence of the original "gold master".

The master disc is then covered with a thin layer of another substance and placed in a electrochemical galvanic bath. The master disc is electrochemically plated with a thick layer of metal. The plated material – which is known as a "stamper" – is separated from the master disc. This stamper is a negative of the master disc and is a negative of the original "gold master". The stamper is used for CD-Rom duplication. Copies are then coated with the aluminium layer and with protective polycarbonate . Then a coloured picture is printed on the face of the disc.

Errors in the disk can be created by various event including noise, loss accuracy in the control of the laser placement and any small deviation in speed of rotation of the disc. These errors generally take the form of a physical displacement along the spiral of the pits on a compact disc. In certain portions of the master disc, especially the edges, this displacement may be especially pronounced.

This displacement of the "pits" results in a deviation in the physical length of the sector from the physical length that would occur in an ideal case. Thus, even two master discs with identical binary information produced on the same machine from the same gold master tend to be slightly different.

This deviation of physical pit spiral location will be different for stampers made from different master discs. Further, the physical lengths of the sectors will also be different for CDs printed using stampers from different master discs. The method of identification is based on the comparison of the lengths using several methods. While the difference is often small it can be determined by special decoding methods using a standard CD-ROM drive. The method of the current invention is sensitive enough that it allows comparison of the lengths of sectors near the edge or the center of different Cd-ROM discs. However, if sectors are pre-marked on the master discs of the same batch the definition of the differences with the usual drive is impossible. This was proved by experiment with the gold (CDR) discs from the same batch. Sectors of the discs were marked to synchronize recording.

One feature of this technique provides compact disk authentication through the mapping of an individual pattern of an original compact disc and comparing this pattern with others. This individual pattern of the physical location of the logical elements on the disc can be called a "Compact Disk Fingerprint". In the current embodiment, the method is used to map only part of the pattern of a compact disc e.g. a pattern related to the sectors on one turn of the disk. The mapping can be done with expensive high precision equipment or a powerful microscope. This embodiment provides a method which can map a CD pattern with ordinary equipment like a PC computer with a CD-ROM drive. There is a functional dependence between the time of reading an individual sector and its physical length on a CD surface.

The current invention can be considered in three parts.

Stage 1. Reading the characteristics of a CD ROM drive.

Because there are variations of CD-ROM drives, when reading a CD one has to consider some parameters of a particular drive, such as inside cache buffer memory and reading speed. The cache buffer is a special memory chip installed on the logic board to serve as a staging or storage area for data ready to be sent to the computer's microprocessor. At this stage one has to calculate the inside cache buffer memory and also reducing the drive speed. Reducing

the drive speed helps to reduce errors of reading CD-ROM discs, i.e. a higher speed results in more errors. The size of cache buffer memory must be known before starting Stage 2(see below). During the procedure of scanning this method fills up the cache buffer memory with blank information for deactivation of the cache buffer memory because otherwise we will receive information of time transfer from cache buffer into processor instead of sector reading time.

FIG. 3 Shows the algorithm for the calculation cache buffer memory size. This algorithm measures the cache buffer memory size in relative units - one sector size.

The programming code of the mentioned algorithm.

```
CACHE_SIZE=100;
  ReadSector(0,1,NULL);
  ReadSector(0,1,&time);
  cachetime=time;
  for(i=CACHE_SIZE;i>0;i-=2)
  {
     ReadSector(0,i,NULL);
     ReadSector(0,1,&time);
     if (time<2*cachetime)break;
  }
 //Total cashe size
 cachesize=i;
```

Stage 2. Scanning a CD disc

The reading process occurs in this stage. It should be noted that during the reading process a data array is formed that stored the time of reading all transmissions from the defined sector to the others. The data array is depicted in FIG.2. The data array has two columns, i.e. sector numbers 20 and reading time 22 from the base sector. The preferred quantity of sectors to be read is not less than about 1000 (the more sectors read more exact the testing). This preferred quantity of sectors is roughly 50 turns.

The process of scanning involves reading the sectors in sequence . For this particular example the base sector is a last sector S18. The direction of sector reading is from the sector S18 to the compact disc centre.

The sequence of reading the sector is thus: S18, S17; S18, 16; S18, S15; S18, S14.........S18; S1. The sector reading time is the sum of two parameters - the time of movement of the reading head from the base sector to the measured sector and the time of the measured sector reading. All data on time reading of each individual sector are stored the in above mentioned array (FIG.2).

Stage 3. The data processing

As soon as received temporary data are stored in the array it is necessary to delete errors. FIG 6. shows the graph 60 before the data processing. These errors are created if the CD drive reads a sector with difficulty. There are a lot of causes of difficulty in reading the disc including damage to the disc. It is necessary to use a filtering algorithm to eliminate defects. Upon studying the saw like graph (FIG. 5), wherein the F axis is the reading time and the Z axis shows the sector number, it is apparent that any variations in the slopes of lines L1, L2, L3 of curve 40 would create some problems. Therefor any variations or leaps that are on the downwardly sloping lines must be smoothed. A "law of the leap" is defined by the following formula.

$Y_{i-1}<Y_i>Y_{i+1}$; where $Y_{i-1}>Y_{i+1}$

Algorithm of smoothing leaps:

```
for(i=1;i<SEEK_SECTOR-1;i++)
{
    if(time[i-1]<time[i]&&time[i+1]<time[i-1])time[i]=(time[i-1]+time      2])/2;
}
```

One the data array is put in order it is necessary to define all methods on the graph and quantities of sectors in each of the above methods define all straight lines on the saw like

graph (lines parallel to the slopes L1, L2, L. First you need to define the basic slope of the line L.

Algorithm of definition of the basic slope:

```
double k=0;
int count=0;
for(i=0;i<SEEK_SECTOR-1;i++)
{
    if(time[i+1]<time[i])
        {
        k+=time[i+1]-time[i];
        count++;
    }
}
k =k / count;
```

Then the algorithm goes through the whole reading time fields of data array and scans all slopes that parallel to the slope *k*.

Algorithm of finding parallel lines:

```
for(i=0;i<SEEK_SECTOR-2;i++)
  {
    double pp=(time[i+2]-time[i])/2;
    if(fabs(1-pp/k)>0.2)continue;
    for(j=i+3;j<SEEK_SECTOR;j++)
    {
      if(time[j]<time[j+1])break;
      double pz=(time[j]-time[i])/(j-i);
      if(fabs(1-pz/k)>0.2)break;
      pp=pz;
    }
```

```
    //forming the line equation
  line.k=pp;
  line.b=-pp*i+time[i];
  i=j;
    //adding a line to the base of lines
  Add(line);
}
```

The processing stage uses the data in the data array to find the distances Y1. Y2..... between line projection T1, T2.... These parameters will determine the quantity of sectors in one turn of the way. Thence, discs are identified by these parameters. During experiments the permissible percentage differences between these measured quantities of the discs being compared was defined.

The final result of the data processing is the number of sectors on at least 50 turns of the disc way. This value is depicted in FIG.4 as Y1, Y2, etc.

In this embodiment the fingerprint or characteristics of the physical location of logical elements of information on the compact disk is the number of sectors on the at least 50 turns. These values are compared with those of original disks. The disk is "original", i.e. not a counterfeit copy if the coincidence is equal to at least 36 percentage.

All data on quantity of sectors in each turn are stored in the array 70 (FIG. 7). The data array has two columns ie turn numbers 74 and quantity of sectors 72.

The disc identification information comprises data array 70 (FIG. 7) and information on the address of the base sector and number of sectors to be scanned. During identification this information can be stored as the fingerprint of the original disc. The fingerprint information can be used on a different PC for disc identification.

While the invention has been described according to what is presently considered to be the most practical and preferred embodiments, it must be understood that the invention is not limited to the disclosed embodiments. Those ordinarily skilled in the art will understand that various modifications and equivalent structures and functions may be made without departing from the spirit and scope of the invention as defined in the claims. Therefore, the invention as defined in the claims must be accorded the broadest possible interpretation so as to encompass all such modifications and equivalent structures and functions.

What is claimed is:

1. A method of identification optical recording medium wherein data are grouped in a substantially as described herein.

2. A method of comparing the optical reading medium on two discs by measuring the correlation between the logical structure of data with the data's physical locations on the discs substantially as described herein.

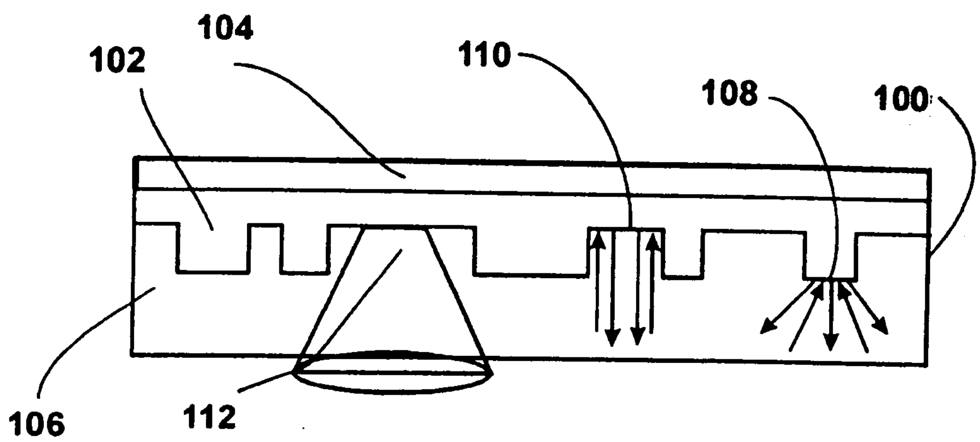

FIG.1

20 22

Sector Numbers	Reading Time
S_0	T_0
S_1	T_1
S_2	T_2
S_3	T_3
.....	.....
S_n	T_n

FIG.2

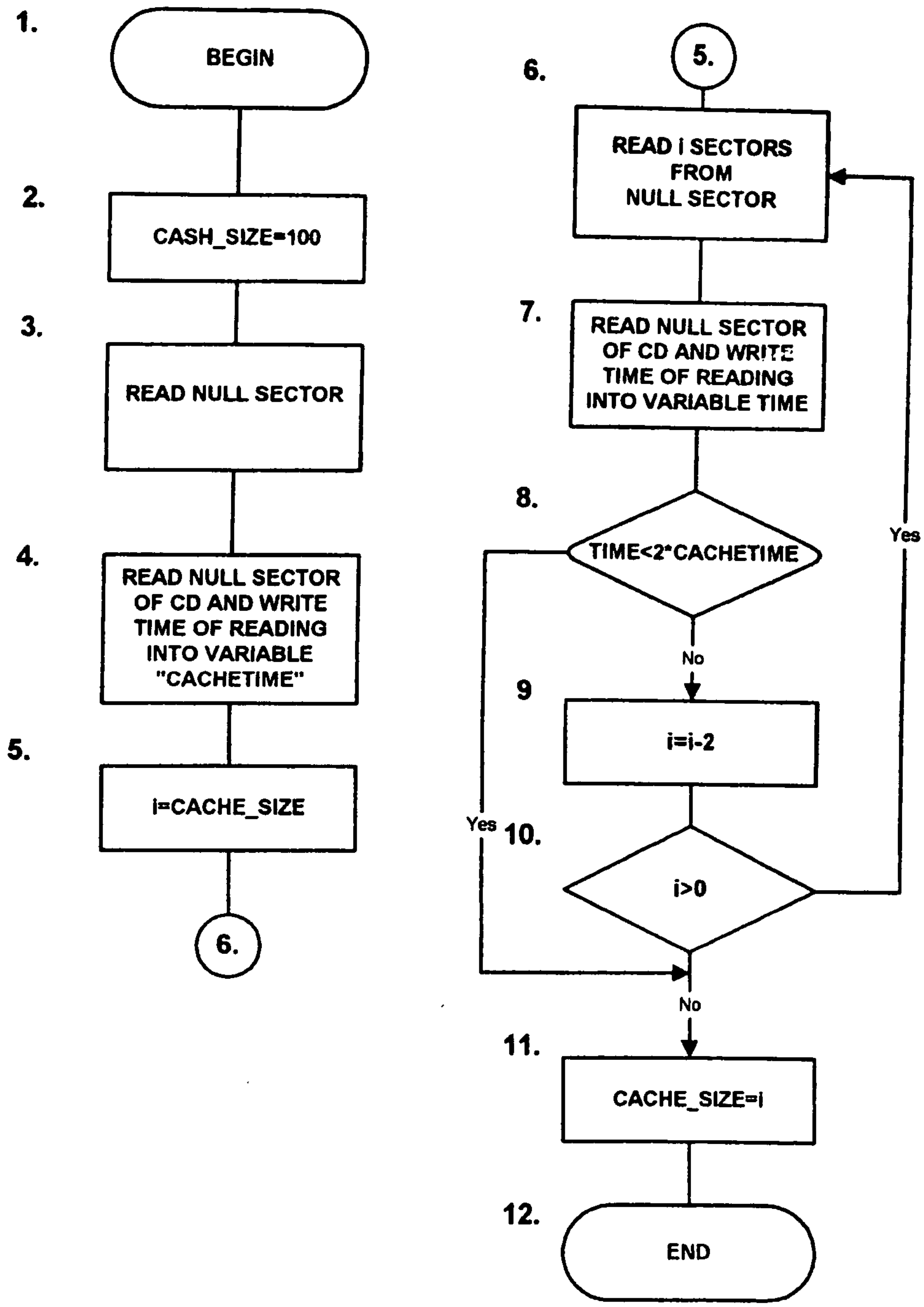
1.
BEGIN
2.
CASH_SIZE=100
3.
READ NULL SECTOR
4.
READ NULL SECTOR OF CD AND WRITE TIME OF READING INTO VARIABLE "CACHETIME"
5.
i=CACHE_SIZE
6.
5.
6.
READ i SECTORS FROM NULL SECTOR
7.
READ NULL SECTOR OF CD AND WRITE TIME OF READING INTO VARIABLE TIME
8.
TIME<2*CACHETIME
Yes
No
9
i=i-2
Yes
10.
i>0
No
11.
CACHE_SIZE=i
12.
END

FIG.3

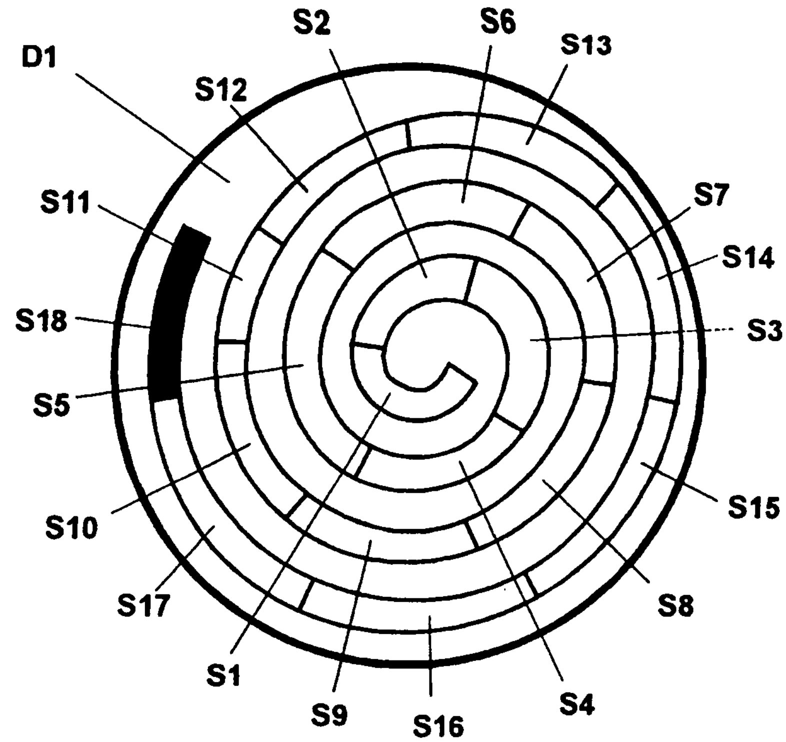

FIG.4

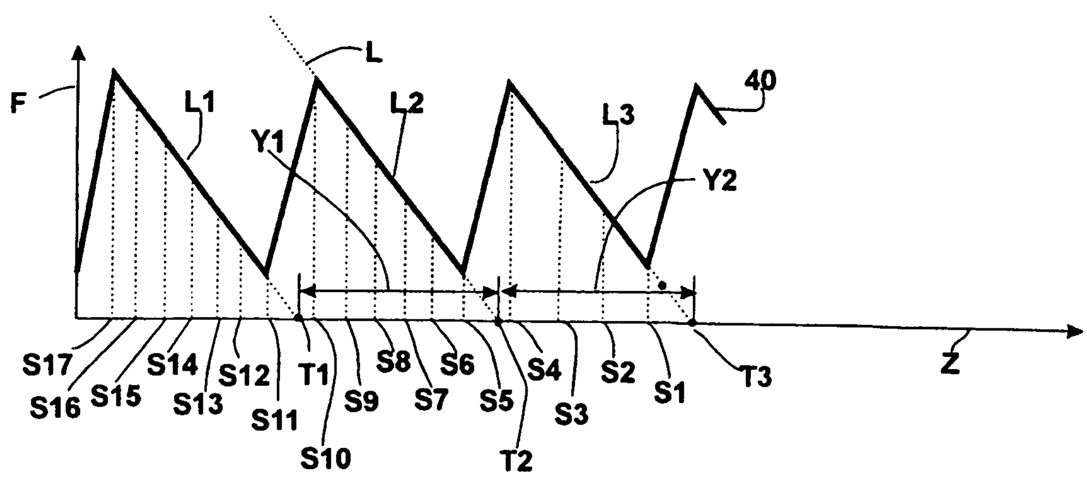

FIG.5

Gowling Lafleur Henderson LLP

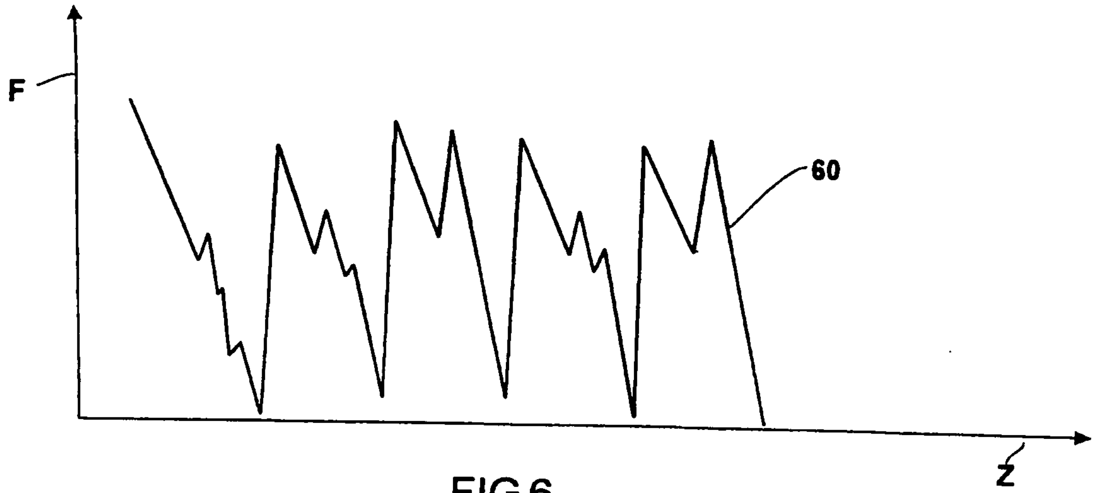

FIG.6

Turn Numbers	Quantity of sectors
Y_0	Q_0
Y_1	Q_1
Y_2	Q_2
Y_3	Q_3
.....	.....
Y_{50}	Q_{50}

FIG.7